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## Welding Technology Transfer Task/Laser Based Weld Joint Tracking System for Compressor Girth Welds

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### ABSTRACT

Sensors to control and monitor the welding operations are currently being developed at Marshall Space Flight Center. The laser based weld bead profiler/torch rotation sensor has been modified to provide a weld joint tracking system for compressor girth welds. The tracking system features a precision laser based vision sensor, automated two axis machine motion, and an industrial PC controller. The system benefits are elimination of weld repairs caused by joint tracking errors which reduces manufacturing costs and increases production output, simplification of tooling, and free costly manufacturing floor space.

### INTRODUCTION

This task is a result of the technology transfer program initiated by NASA to transfer aerospace developed technology into the private sector to improve quality and productivity.

The Marshall Automated Welding System Development Program for the shuttle external tank, advanced solid rocket motor casings, and National Launch System(NLS) vehicle includes the development of optical sensors to control and monitor the welding operations. The laser based weld bead profiler/torch rotation sensor has been modified and new software developed to provide a laser based weld joint tracking system for compressor girth welds, which utilize the Gas Metal Arc Welding Process(GMAW), for Copeland Corporation.

### REVIEW OF COPELAND'S WELDING PROCESS AND TOOLING

#### General Information

The compressor shells are .120" thick(nominal) draw quality 1008/1010 mild steel. Copeland utilizes the GMAW weld process. Copeland has five weld stations.

A typical weld cycle is listed below:

- 1) An operator loads a compressor shell onto the rotary table and actuates overhead air ram to hold the unit in place.
- 2) The operator then actuates the mechanical weld seam finding arm. After the seam is mechanically "found", a secondary arm with a hardened tracing stylus and the GMAW torch tooling contacts the lip of the lower half of the compressor shell. The table then begins to rotate and the weld portion of the cycle is initiated.
- 3) When the table completes one revolution plus approximately 3/4" for weld overlap, the table returns to its initial preset start point.
- 4) The torch tooling retracts and the air ram releases and the operator pushes the welded unit onto a section of roller conveyor ready to load another unit in place.
- 5) The welders average 550 to 650 weld cycles/shift.

#### Problem Statement

The current mechanical positioning devices are not capable of "real time" corrections due to variations in ideal weld joints of the compressor shells. Also, the current process requires special tooling(elliptical shaped gears) which offsets the shape of the part for the welding operation.

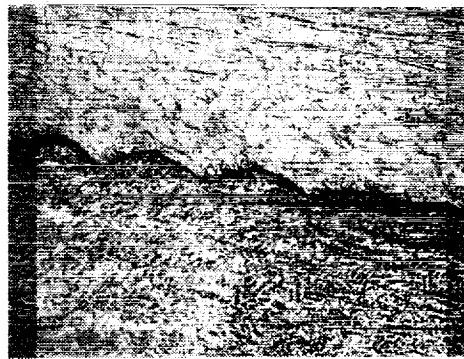
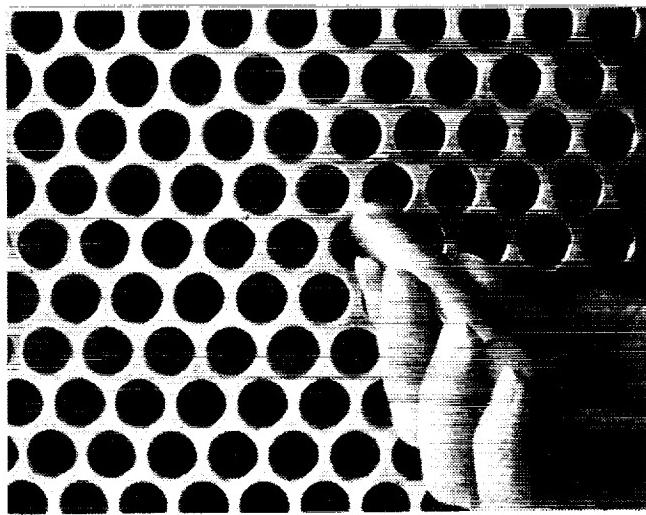


Figure 12. Tools for explosive plugging of heat exchangers Metallurgical bond is shown in the lower right.

## **OBJECTIVE**

Provide a weld joint tracking system that maintains the correct weld joint path and standoff distance which will eliminate weld defects/repairs caused by joint tracking errors during compressor girth welding operations. Demonstrate that a direct drive turntable may be used with this system which would eliminate/reduce some of the tooling and maintenance costs associated with the present tooling and reduce the floor space needed for a weld station.

## **SCOPE OF WORK**

Modify the laser based weld bead profiler/torch rotation sensor and develop the software to provide a computer controlled weld joint tracking system which maintains the correct weld path and standoff (torch to work distance) during compressor girth welding operations. The system must be adaptable to both the existing Copeland tooling and a simple direct drive turntable setup.

Design and fabricate the fixturing for the weld joint tracking system to be compatible with the existing Copeland weld station equipment.

Perform the initial testing and demonstration of the tracking system utilizing the weld system and tooling at MSFC.

Install, checkout, and demonstrate the system at Copeland Corporation.

## **LASER BASED WELD TRACKING SYSTEM**

### System Features

The tracking system features are as follows:

- 1) Precision laser based vision sensor - The sensor illuminates a line across the weld joint with a pulsed, fan-shaped beam of light from a laser diode. Light reflected from the illuminated area is imaged in a camera, the shutter of which can be opened during times as short as 100ns. The laser pulse is synchronized with the opening of the shutter to maximize the amount of laser light integrated. The amount of arc light integrated is minimized as a result of keeping the opening time short. The sensor operates in conjunction with a video digitizer and a computer. By use of a geometric transformation based on the position and orientation of the camera with respect to the fan of light and the workpiece, the computer controls the position of the torch with respect to the weld joint.<sup>1</sup>
- 2) Automated two axis machine motion
- 3) Industrial PC controller
- 4) The system is invariant to travel rate changes.

Photographs of the system hardware features at MSFC are attached.

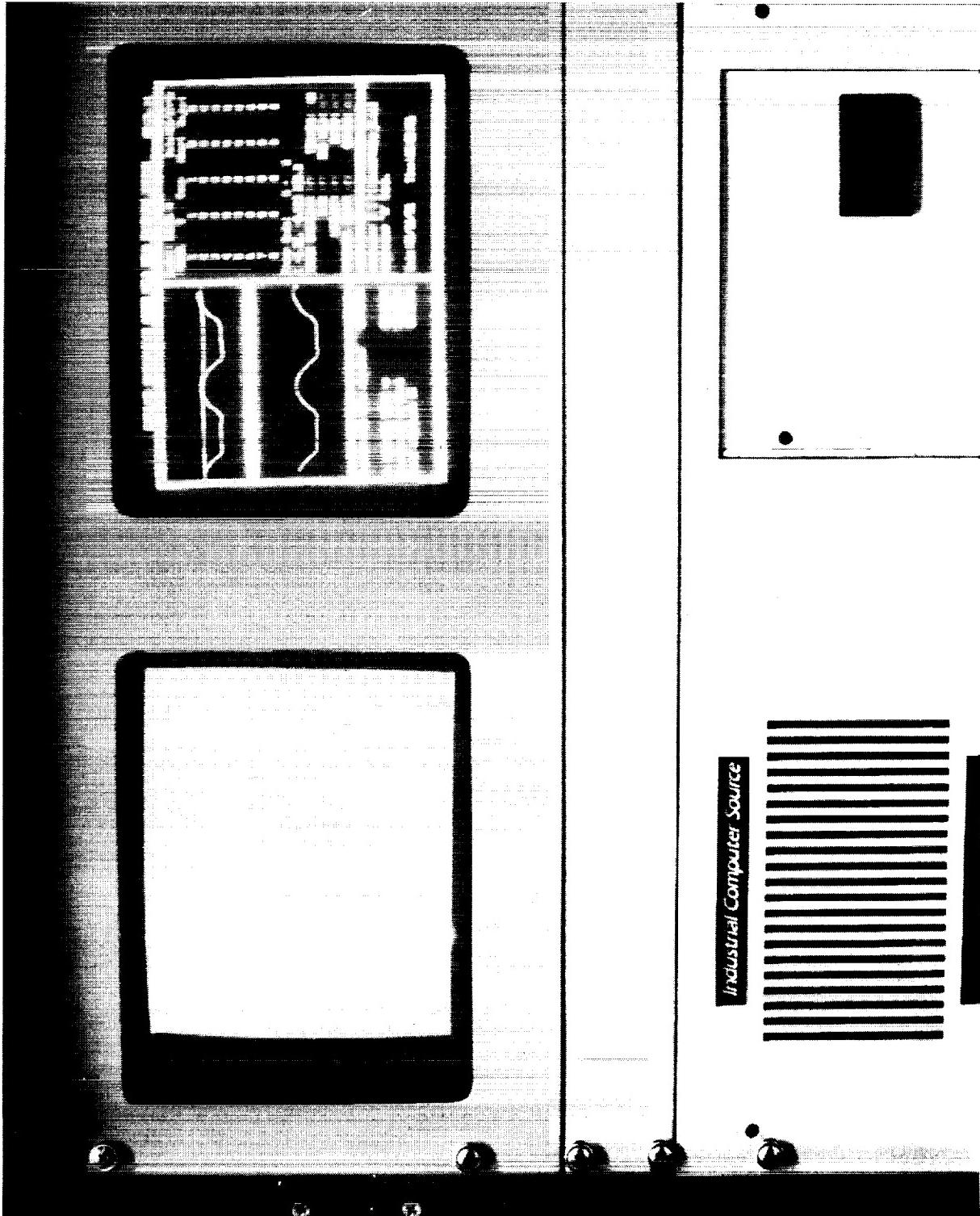
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<sup>1</sup> NASA Tech Briefs, April 1991, Page 40

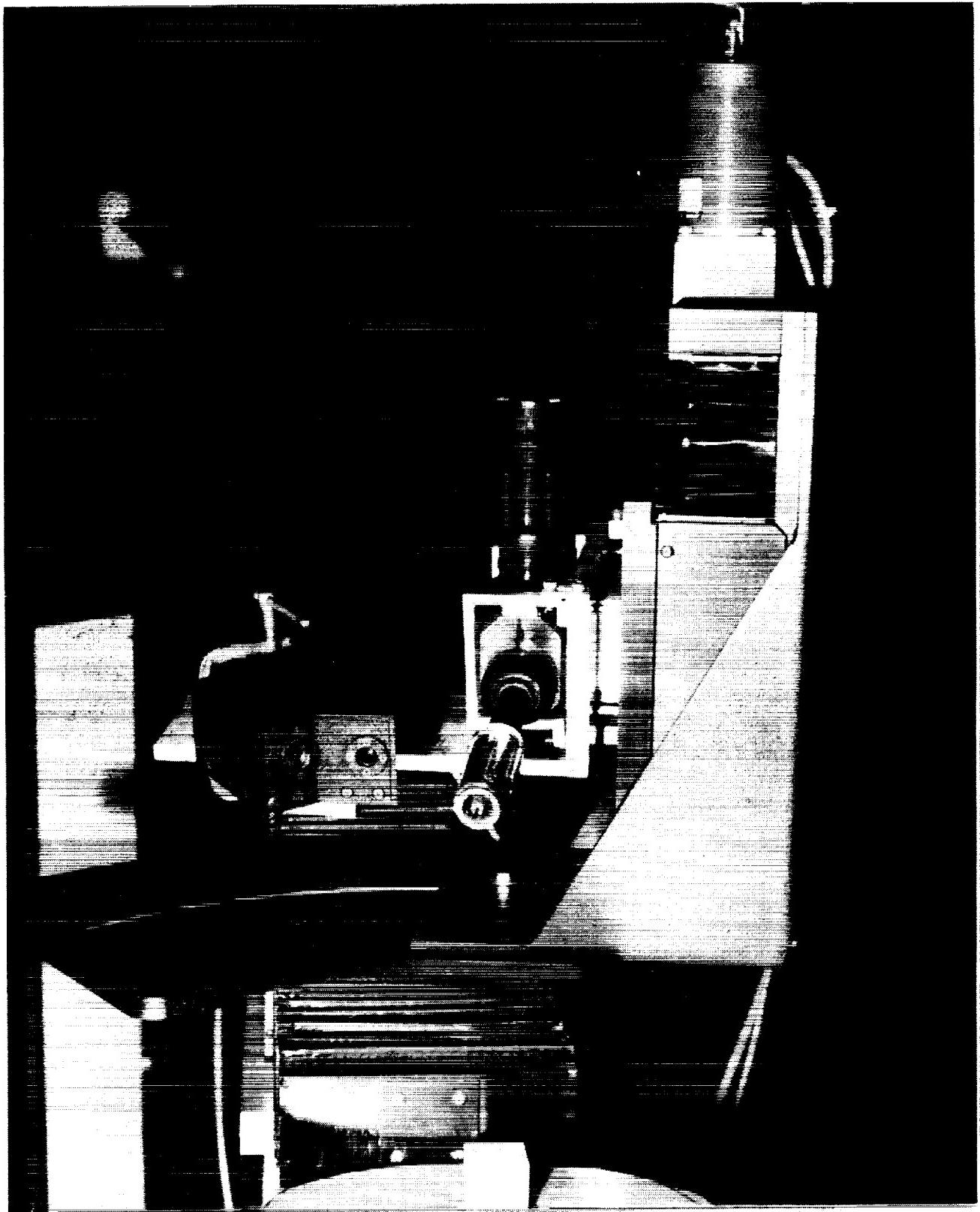
### **System Benefits**

As a result of the system operation capability demonstrated at MSFC, the immediate benefits which have been identified are as follows:

- 1) Elimination of weld repairs caused by joint tracking errors which results in reduced manufacturing costs and increased production output
- 2) Simplification of tooling, i.e. the capability to use simple direct drive turntables
- 3) Free costly manufacturing floor space

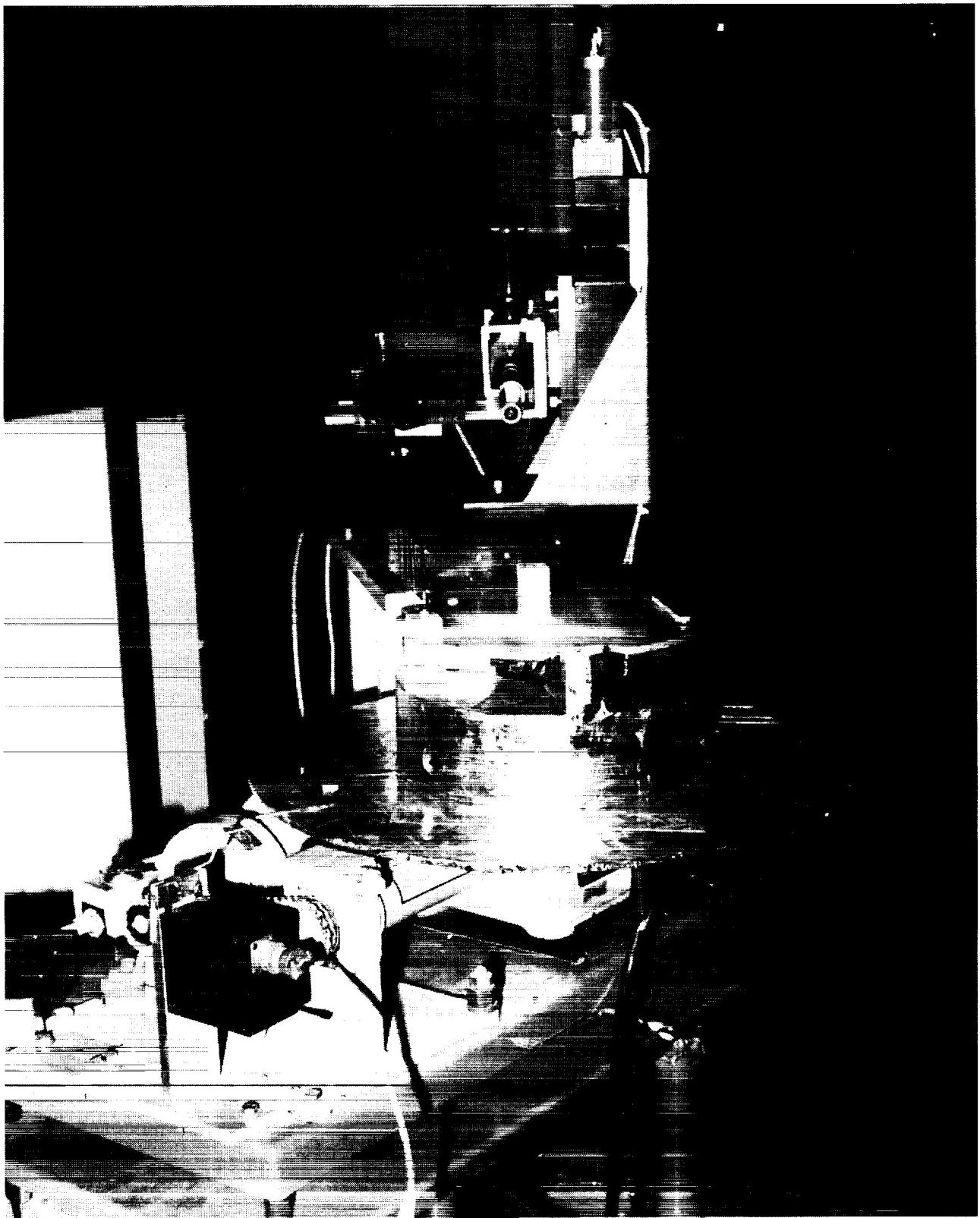


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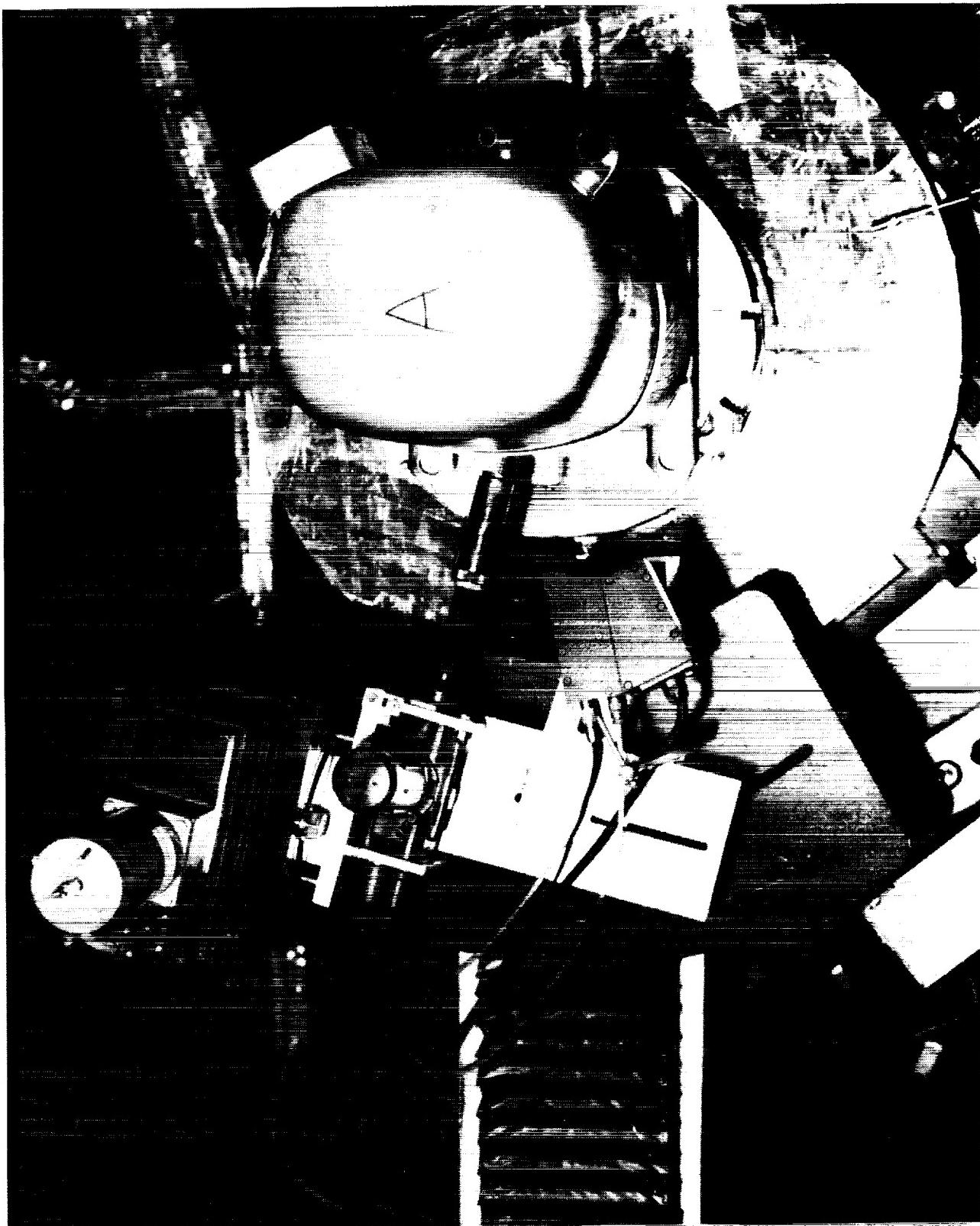
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TASK FOR THE COPELAND CORP.**

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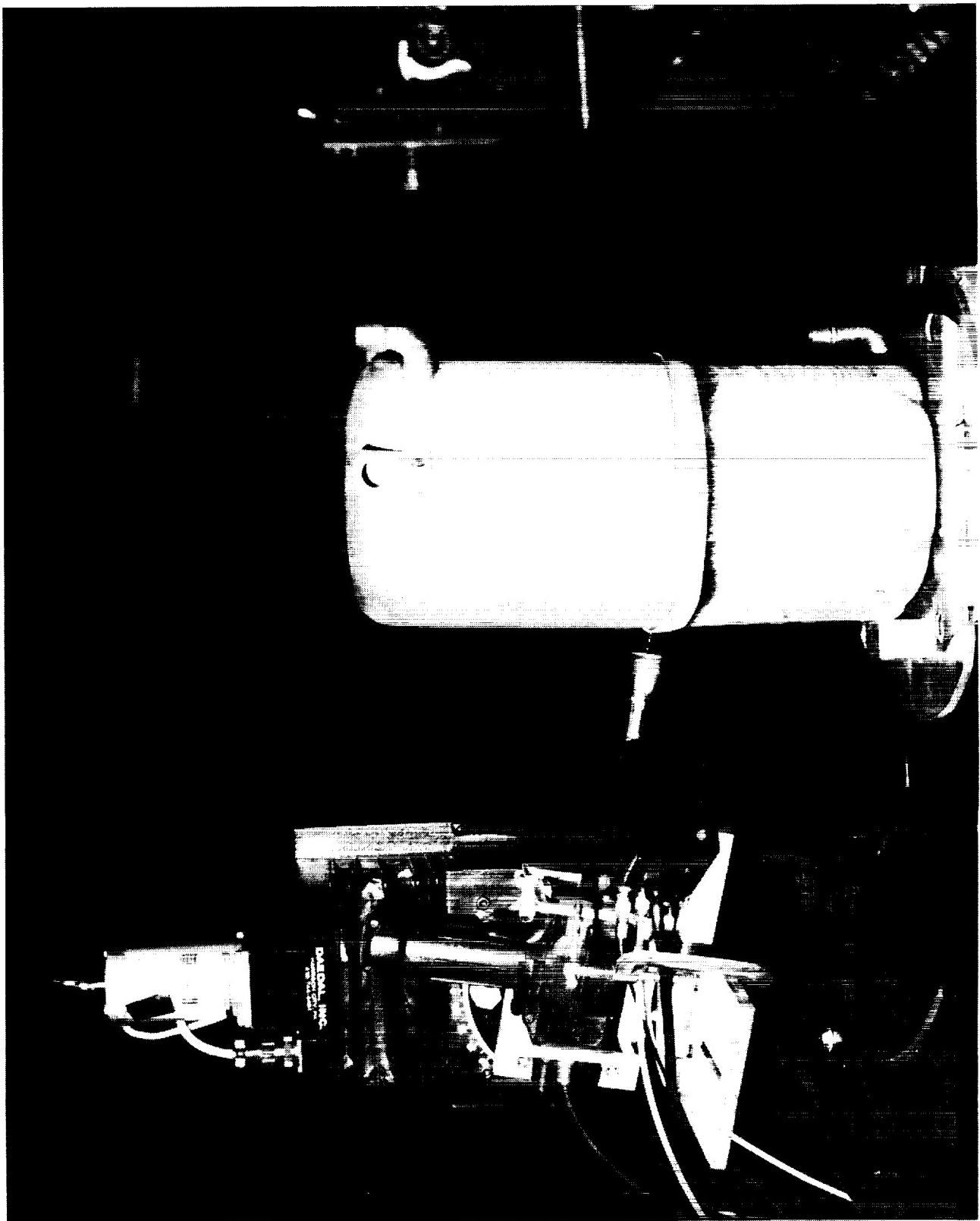
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